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SINCLAIR WEEKS, Secretary
WEATHER BUREAU
F. W. REICHELDERFER, Chief

KEY TO METEOROLOGICAL RECORDS DOCUMENTATION NO. 3.081

EXCESSIVE PRECIPITATION TECHNIQUES

A summary of the instructions for computation of excessive precipitation in the U. S. Weather Bureau.

Washington, D. C. 1958

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PURPOSE

The Key to Meteorological Records Documentation Series has been established to provide guidance information to research personnel making use of climatological data.

Frequently users of such data have found it necessary to spend a great deal of time establishing whether the criteria for observing or computing various elements have changed over the period of record.

It is therefore hoped that the presentation of this series may not only conserve valuable time but may have a direct influence in improving the accuracy of research results.

PREFACE

This publication is a part of the Key to Meteorological Records Documentation Series and presents a resume of the rules under which excessive precipitation was and is computed in the Weather Bureau. Special attention is called to discontinuity of the methods used before and after January 1, 1936.

A summary of excessive precipitation data for the years prior to 1896 was published in the annual report of the Chief of the Weather Bureau for 1895-1896. Excessive precipitation data for the years 1896-1934 were published in the annual reports of the Chief of the Weather Bureau, with these same data for 1897 through 1920 also published in the Monthly Weather Review. Excessive data for 1935-1949 were included in the appropriate issue of the United States Meteorological Yearbook while data for 1950 and succeeding years have been included in the annual issues of Climatological Data, National Summary.

J. H. Hagarty
Office of Climatology

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PART I RESUME OF HISTORY OF SHORT-DURATION EXCESSIVE PRECIPITATION

Instructions for determining excessive precipitation values on an accumulated basis (all durations beginning at the same point of time and accumulating for the various intervals) were first included in the 1904 Instructions for Preparing Meteorological Forms. However, on page 364 of the "Report of the Chief of the Weather Bureau 1896-1897" are listed excessive precipitation occurrences at Savannah, Georgia and St. Louis, Mo. during 1889-1896 and at Washington, D.C. 1881-1896. These appear to be earliest record of excessive precipitation on an accumulated basis.

This same method remained in effect without substantial change through 1935. Precipitation was considered to be excessive when the rate of .01 t + .20 inch (t= time in minutes) was equalled or exceeded. In 1933 a further provision was included which required that the fall for 1 hour or less must be 1 inch or more. In 1934 a rate of .02t+ .30 was set up for stations in the States of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas with .01t + .20 rate continued for all other areas. Puerto Rico was included in the .02t = .30 group effective with January 1, 1935.

Effective January 1, 1936 a change was made in the method of computing excessive values. The latter method shows the maximum fall for each of the durations - 5, 10, 15, 20, 30, 45, 60, 80, 100, 120, 150 and 180 minutes, even though the fall within some of these time intervals may not have reached the established "excessive" rate. (The 15-minute values were dropped from 1936-1943, and the 150-minute values were dropped from 1944-1948).

The rates at which precipitation was considered excessive for 1936 through 1948 were as follows:

TIME	AMOUNT
5 minutes	.25 In.
10	.30
15	.35
20	.40
30	.50
45	.65
60	.80
80	1.00
100	1.20
120	1.40
150	1.70
180	2.00

The above rates applied to all stations except those in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, and Texas where the following rate applied:

TIME	AMOUNT
5 minutes	.40 In.
10	.50
15	.60
20	.70
30	.90
45	1.20
60	1.50
80	1.90
100	2.30
120	2.70
150	3.30
180	3.90

Beginning in 1949 use of the second table was discontinued and the rate of .01t + .20 was established for all areas.

Although more detailed instructions were issued effective November 1, 1951, no appreciable changes have been made through 1957.

PART Ia CHRONOLOGICAL SUMMARY OF HISTORY OF SHORT DURATION EXCESSIVE PRECIPITATION INSTRUCTIONS

YEAR

1904 First Instructions. Rate of .01t + .20 inch (t= time in minutes) must be equaled or exceeded. All durations begin at the same point of time and accumulate for the various intervals.

1933 Added requirement, the fall in one hour or less must be 1 inch or more.

1934 Rate of .02t + .30 was set up for stations in the States of Alabama, Arkansas, Florida Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas.

1935 Puerto Rico was added to the .02t + .30 group.

1936 Accumulative method was no longer used. Values are the maximum falls for each of the durations 5, 10, 15, 20, 30, 45, 60, 80, 100, 120, 150, and 180 minutes, even though the fall within some of these time intervals may not have reached the established excessive rate. The rates were .01t + .20 for all states except Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Puerto Rico where the rate was .02t + .30.

1936 15-minute interval dropped.

1944 15-minute interval resumed.

1944 150-minute interval dropped.

1949 Rate of .02t + .30 was discontinued, and rate of .01t + .20 was substituted for all areas.

1951 More detailed instructions issued in Circular N; no substantial changes involved.

PART Ib HISTORY OF SHORT DURATION EXCESSIVE PRECIPITATION

Below are the first instructions for tabulating excessive precipitation. These were carried as paragraphs 141 and 142 in the 1904 Instructions for Preparing Meteorological Forms. Paragraph numbers were changed to 205 and 206 in 1905 and to 200 and 201 in 1918. The second sentence in paragraph 142 was only for 1904 and the amount of .75 inch in the second table was changed to .80 in the 1907 instructions.

"141. In tabulating excessive precipitation data on Forms No. 1017 and No. 1028 for storms in which the rate of fall equals or exceeds the limits shown in the following table, the accumulated amounts for each successive interval of five, ten, fifteen minutes, etc., during which the precipitation continues at an excessive rate will be entered in the table provided for that purpose on the back of the forms. Under the head "Total duration" will be entered the beginning and ending of precipitation; under "Excessive rate" will be entered the time precipitation began to fall at an excessive rate, which will not be less than 0.05 inch in five minutes, and the time the precipitation fell below that rate. This, however, must not be construed to mean that short periods during the progress of a storm where the rate falls temporarily below this limit shall be excluded. When the rate falls below the lowest limit, 0.05 inch in five minutes, for a period of thirty minutes or more, the succeeding excessive precipitation will be tabulated separately. Under the heading "Accumulated depths of precipitation, etc.," will be entered accumulated amounts for the respective periods, all periods beginning at the same point of time, which should be identical with that given under "Excessive rate, began." The tabulation will be continued so long as the excessive rate, as indicated above, continues. When the excessive rate extends beyond one hundred and twenty minutes, the tabulation will be made for each fifty minutes separately, so long as the excessive rate continues.

EXAMPLE

Excessive Rate		Amount before excessive began	Depths of precipitation (in inches) during periods of time indicated.									
Began	Ended		5 min	10 min	15 min	20 min	25 min	30 min	35 min	40 min	45 min	50 min
7.00 AM	7.50 AM	2.66	0.08	0.25	0.38	0.52	0.77	0.88	0.92	1.28	1.42	1.80
7.50 AM	8.40 AM	----	2.05	2.24	2.42	2.61	2.82	2.86	2.91	2.94	3.10	3.30
8.40 AM	9.30 AM	----	3.53	3.61	3.78	3.92	4.19	4.29	4.35	4.45	4.64	4.70

Table showing limits at which precipitation may be considered as excessive:

Duration in Minutes	Depth of precipitation in inches	Duration in minutes	Depth of precipitation in inches
5	0.25	35	0.55
10	0.30	40	0.60
15	0.35	45	0.65
20	0.40	50	0.70
25	0.45	60	* 0.75
30	0.50		

142. "Storms in which the amount of fall does not equal that given above for any of the periods of time will not be tabulated. A note will be made on the back of the last register sheet for the month showing on which dates excessive precipitation occurred; if none occurred, it should be so stated. **"

In 1933 paragraph 200 remained unchanged, but paragraph 201 was changed to:

"The accumulated depths will be tabulated when the fall equals or exceed the rates mentioned in paragraph 200, provided the fall for 1 hour or less is 1 inch or more. If the rainfall is less than 1 inch in an hour, the accumulated depths will not be tabulated, notwithstanding that rates may equal or exceed those mentioned in paragraph 200."

In 1934 the same rules remained in effect except that a rate of .02t + .30 is provided for stations in States of Alabama, Arkansas, Florida, Georgia, Louisiana, North Carolina, Mississippi, Oklahoma, South Carolina, Tennessee, and Texas, while the rate of .01t + .20 remained in effect for the rest of the States - also all tabulations were to be continued to the 120-minute duration when even the excessive rate ends before that time. Effective January 1, 1935 Puerto Rico was included in the above group.

The following were carried as paragraphs 200 and 201 in the 1936 and 1937 Instructions for Preparing Meteorological Forms:

"Beginning January 1, 1936 in tabulating excessive precipitation data from Forms 1017 for storms in which the rate of fall equals or exceeds the limits shown in the 2 tables, the maximum amount for each period will be entered in the spaces provided for that purpose on page 14, Form 1001. No matter how brief the excessive duration, the maximum amount for each one of the periods will be recorded.

Tables showing limits at which precipitation may be considered excessive.

* Changed to .80 in 1907 Instr.
** Omitted after 1904.

Table I - for stations not in sections mentioned in Table II.

Duration in Minutes	Depth, inches
5	.25
10	.30
15	.35
20	.40
25	.45
30	.50
35	.55
40	.60
45	.65
50	.70
60	.80
80	1.00

Table II (for stations in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, Puerto Rico. South Carolina, Tennessee, and Texas.)

Duration in Minutes	Depth, inches
5	.40
10	.50
15	.60
20	.70
25	.80
30	.90
35	1.00
40	1.10
45	1.20
50	1.30
60	1.50
80	1.90

These same instructions were continued in 1939 plus the following two paragraphs:

"Table I is made up from the formula A= t + .20 (.01t + .20) and Table II from the formula A= 2t + .30 (.02t + .30). A is the accumulated depth in hundredths of inches and t is the time in minutes.

In obtaining the maximum amounts of precipitation the first tip should not be included in the period unless the beginning of the shower comes within the period."

The preceding instructions remained practically unchanged through the 1948 (last) edition of Instructions for Meteorological Forms. The 1948 instructions did state that when obtained from weighing gage charts, determination will be for 15 minute intervals; also that when daily amounts occur on parts of 2 days, a bracket should indicate this.

Use of Table II (.02t + .30) was discontinued at the end of 1948 and Table I was used for 1949 and following years for all stations.

In November 1951 the instructions were elaborated upon (but not changed in any important respect.) See the attached copies of paragraph.A4530, A4530.1, A4530.2, A4530.3 and A4531 of Circular N Addendum.

The instructions were repeated, but not changed materially, in paragraph 4390, 4390.1, 4390.2 and 4391 in Change No. 4 of Circular N. dated 10-1-57.

A4530. Excessive Precipitation (Col. 90) --Precipitation is termed "excessive" when it equals or exceeds the amount specified for any one of the time-intervals listed in Table A4-1. Excessive precipitation data will be evaluated at first-order stations 1/ equipped with a recording gage that is used for the station record (see paragraph 4030).

A4530.1. Whenever there are two or more separate time-intervals of excessive precipitation, successive time-intervals are regarded as belonging to the same period when:

(1) They occur less than 180 minutes apart, irrespective of the amount of intervening precipitation.

(2) They occur 180 minutes or more apart, and the amount of intervening precipitation equals 1.80 inches or more for every period of 180 consecutive minutes (0200 to 0500, 0201 to 0501, etc.)

When these conditions are not satisfied, successive time-intervals are regarded as being in separate periods. When there is only one time-interval of excessive precipitation, the duration of the period is the same as that of the time-interval. When there are two or more time-intervals in a single period, the duration of the period is the elapsed time between the beginning and end of the first and last intervals, respectively.

A4530.2. The maximum precipitation for all the time-intervals listed in Table A4-1 will be computed for each period of excessive precipitation (see Fig. A4-10 or A4-11). The various time-intervals have no chronological relationship to each other, but each time-interval must be related in one of the following ways to the period of excessive precipitation by:

(1) Beginning in the period

(2) Ending in the period

(3) Including the period

(4) Being included by the period

A4530.3. The precipitation scale M000-21 may be used for evaluating maximum precipitation data on Form 1017 or 1017B (see Fig. A4-10). A pair of dividers may be used to assist in evaluating either this record or that of the weighing-type gage. Using the time lines on the record as a scale, set the dividers to equal the number of minutes in the time-interval being considered, and then determine the amount of precipitation bracketed by the dividers.

TABLE A4-1
EXCESSIVE PRECIPITATION

Time-interval (minutes)	Depth of Precipitation (inches)	Time-interval (minutes)	Depth of precipitation (inches)
5	0.25	60	0.80
10	0.30	80	1.00
15	0.35	100	1.20
20	0.40	120	1.40
30	0.50	150	1.70
45	0.65	180	2.00

A4531. Excessive precipitation data will be entered in column 90 of WBAN-10B and in summary form annually or Form 4036. A rubber stamp is used to provide and identify spaces for the tabulation of these data. A separate tabulation will be made for each period of excessive precipitation in accordance with the following:

1/ In localities having both an airport station and a city office, excessive precipitation will be computed for the city office only.

(1) The maximum amount determined in accordance with paragraph A4530.2 for each of the twelve intervals in Table A4-1 will be entered in the appropriate spaces. When equal intervals for adjacent periods overlap in part (see Fig. A4-12):

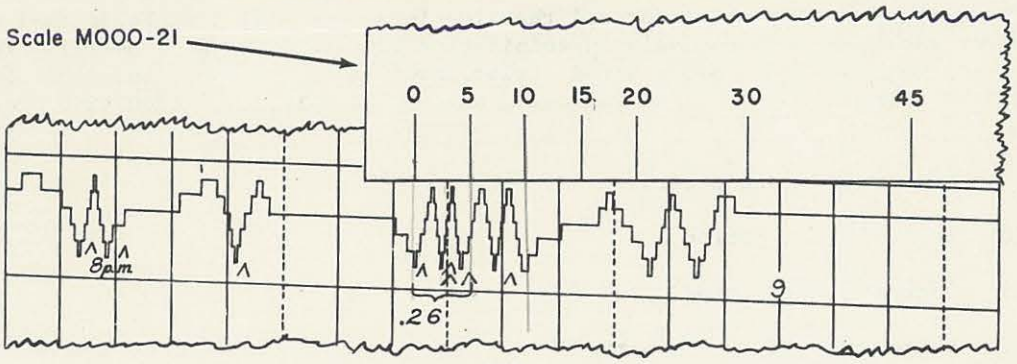
(a) Enter the greater amount in the tabulation for the corresponding period and enter a dash in the appropriate space of the other tabulation.

(b) When the amounts are equal, enter the value in the tabulation for the first period and a dash in the following.

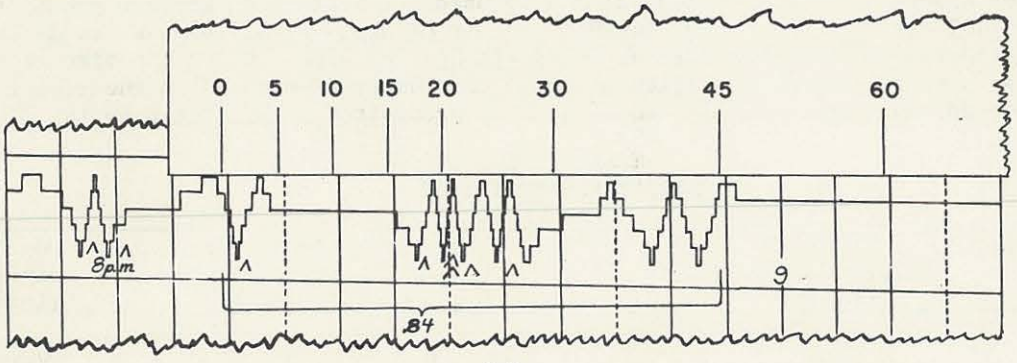
(2) Underscore all maximum amounts that equal or exceed the values specified in Table A4-1 for corresponding intervals of time.

(3) On WBAN-10B, tabulate excessive precipitation data on the form pertaining to the day in which the period ends. Enter these data on Form 4036 in chronological order, and ascribe to each tabulation the day in which the period ends.

(4) When excessive precipitation data cannot be evaluated for all intervals because of an incomplete record, enter an "M" in lieu of the missing values.



(A)

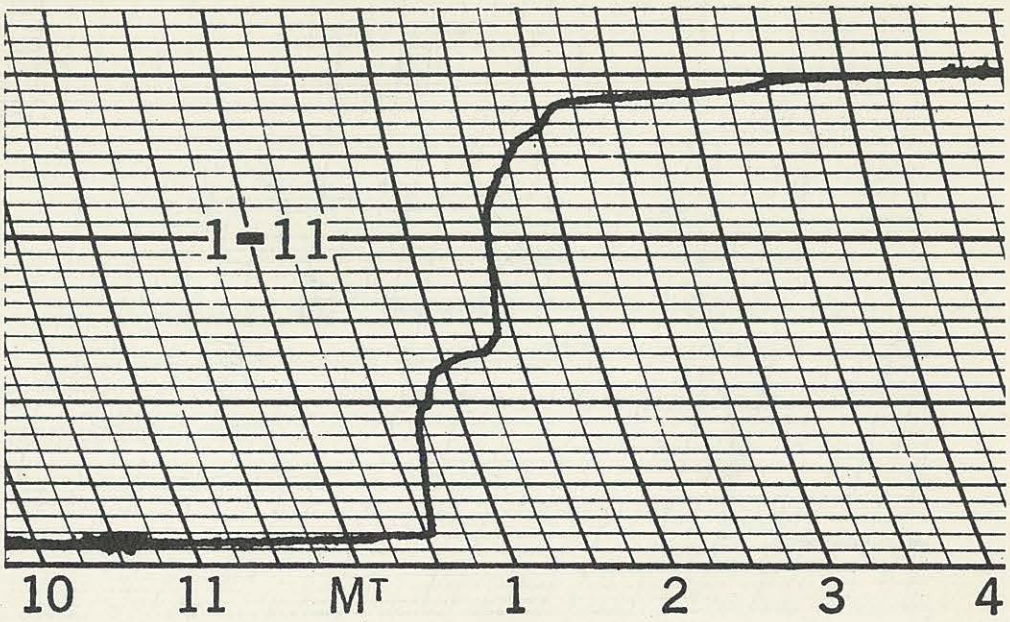


(B)

Duration interval (minutes)	Time of beginning	Max. amount (.00 inch)	Duration interval (minutes)	Time of Beginning	Max. amount (.00 inch)
5	8:27 p.m.	0.26	60	7:54 p.m.	1.05
10	8:27	0.45	80	7:50	1.10
15	8:27	0.48	100	7:50	1.10
20	8:27	0.53	120	7:50	1.10
30	8:27	0.71	150	7:50	1.10
45	8:09	0.84	180	7:50	1.10

(C)

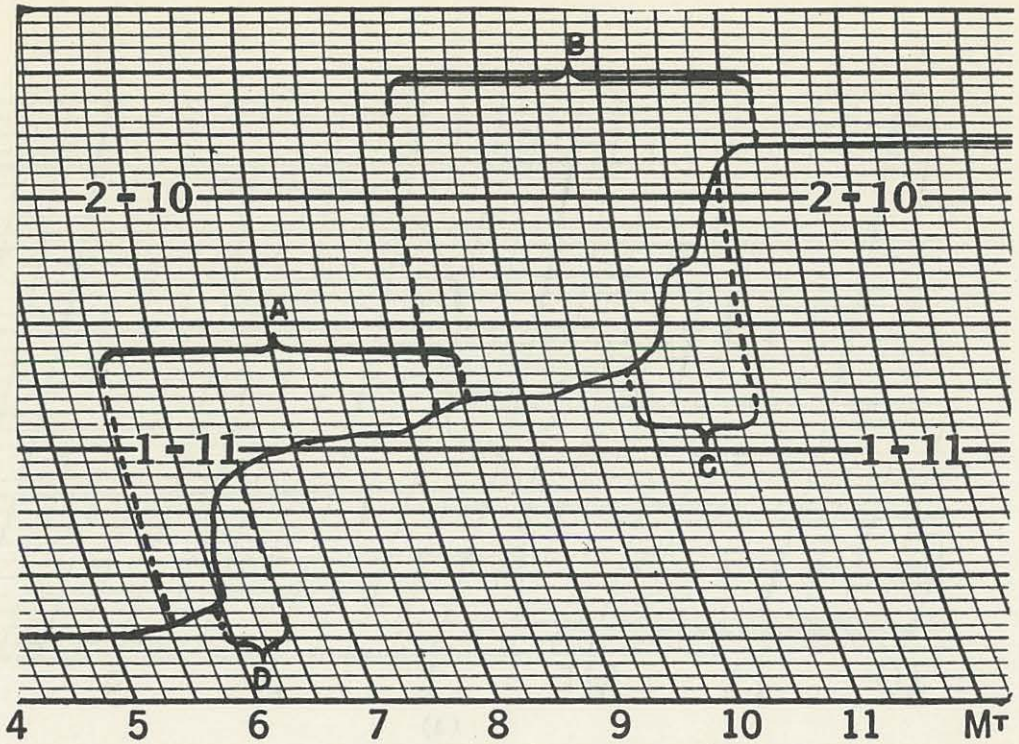
Fig. A4-10. Evaluation of excessive precipitation data - tipping-bucket rain-gage record (Form 1017). The use of the M000-21 precipitation scale in selecting maximum amounts is illustrated in (A) and (B) for intervals of 5 and 45 minutes, respectively. The tabulation in (C) shows the maximum amounts selected for each of the 12 intervals in Table A4-1, and shows the time of beginning of each interval. Maximum amounts that are excessive are underscored.



(A)

Duration of interval (minutes)	Precipitation Time of beginning	Maximum amount (hundredths inch)
5	1:25 a.m.	0.17
10	1:25	0.33
15	1:20	0.44
20	1:20	0.51
30	1:20	0.62
45	1:20	0.70
60	12:35	0.94
80	12:30	1.20
100	12:30	1.31
120	12:30	1.33
150	12:30	1.35
180	12:30	1.38

Fig. A4-11. Evaluation of excessive precipitation data - weighing raingage record (Form 1028C). The maximum amount of precipitation for each of the 12 intervals of time listed in Table A4-1 pertaining to the record illustrated in (A), and the time of beginning of record for each interval, are tabulated in (B). Maximum amounts that are excessive are underscored.



Interval	5	10	15	20	30	45	60	80	100	120	150	180
Amounts for period D	.20	.35	.43	.46	.52	.58	.63	.69	.73	.76	.80	—
Amounts for period C	.18	.25	.33	.38	.45	.70	.82	.90	.95	1.00	1.00	1.06

Fig. A4-12. Excessive precipitation data. "A" indicates the time of occurrence of the maximum amount of precipitation associated with the period of excessive precipitation "D" for an interval of 180 minutes. Similarly, "B" indicates the maximum amount for 180 minutes associated with the period "C". The tabulation lists the excessive precipitation data for the two periods of excessive precipitation. Note that "C" and "D" are separate periods of excessive precipitation, since they are separated by 180 minutes or more (203 minutes) in which the maximum amount of precipitation for 180 minutes does not equal or exceed 1.80 inch. Also note that since "A" and "B" overlap, only the greater amount is tabulated (see the entry for the 180-minute interval of the tabulation for period "C").

PART II RESUME OF HISTORY OF INSTRUCTIONS FOR COMPUTATION OF EXCESSIVE PRECIPITATION AT RATES OF 1.00 INCH PER HOUR AND 2.50 INCHES IN 24 HOURS

Precipitation equalling or exceeding the rates of 1.00 inch per hour and 2.50 inches in 24 hours was computed substantially without change in methods from 1888 through 1943 when these computations were discontinued. These data were published in the Monthly Weather Review from 1894 through 1899.

PART IIa CHRONOLOGICAL SUMMARY OF HISTORY OF INSTRUCTIONS FOR COMPUTATION OF EXCESSIVE PRECIPITATION AT RATES OF 1.00 INCH PER HOUR AND 2.50 INCHES IN 24 HOURS

Year	
1888	Computations started
1943	Computations discontinued.

PART IIb HISTORY OF INSTRUCTIONS FOR COMPUTATION OF EXCESSIVE PRECIPITATION AT RATE OF 1.00 INCH PER HOUR IN 24 HOURS AND 2.50 INCHES

The Report of Chief of Weather Bureau 1896-1897, page 362, stated that "beginning in 1888 rains of 2.50 or more in 24 hours and of 1 inch or more in an hour were classed as 'excessive' and have since been regularly published in the Monthly Weather Review under that title."

General Instruction U.S. Signal Service (predecessor of the Weather Bureau) for 1891 stated that precipitation will be considered excessive when it equals or exceeds 2.50 inches in 24 consecutive hours, or 1 inch in 1 hour.

Paragraph 96 (1) of 1904 Instructions for Preparing Meteorological Forms repeated the above and added: "In determining the duration of excessive precipitation of 2.50 inches in 24 hours at stations equipped with recording rain gages the period of duration will begin with the first closing of the circuit and end with the last closing for each shower. All intervals between showers will be excluded. At stations not equipped with recording gages the period of duration will be the time precipitation actually occurred. When the above data are entered on Forms No. 1001, No. 1002 or compiled for publication the following footnote will be made. "The duration was the time precipitation was actually recorded." The same instructions were carried as paragraph 122 (1) of the 1905 Instructions, and the following was added: "Excessive precipitation at the rate of 1 inch an hour will not be entered on Form 1001-Metl. unless 1 inch falls within an hour. If 1 inch is recorded in less than an hour that amount only will be taken, unless the rate of fall continues excessive (at the rate of 1 inch an hour, or 8 1/3 hundredths inch in 5 minutes) in which event the entire amount of precipitation at the excessive rate and the entire time at which the rate was excessive will be entered.

"After 1 inch has been recorded in an hour, if the rate ceases to be excessive for a short time and again becomes excessive, whether or not it extends beyond one hour, both amounts will be included, provided the amount for the last excessive period is sufficient to make it and the non-excessive interval, taken together, excessive"

"At the beginning or ending of excessive precipitation of 1 inch an hour no amount at less than that rate will be included unless required to make a total of 1 inch in an hour."

The same instructions appear in the 1907 and 1908 Instructions with the following addition: "The period may be extended beyond 24 hours as long as the rate of 2.50 inches in 24 hours continues."

The same instructions also were included in the 1909 Instructions, with the following addition: "In compiling maximum precipitation in 24 hours and excessive precipitation data, the division of the months will be disregarded. The same data will not be included in the compilations for 2 months. When the record for the first of a month has been included in that for a preceding month, a note to that effect will be entered on page 9."

These instructions remained in effect for years. Essentially the same instructions are contained in paragraph 120 (1) of the 1939 Instructions, and in paragraphs 82 through 87 of the mimeographed instructions effective January 1, 1940.

Computation of excessive at 2.50 in 24 hours, and 1.00 inch per hour continued thru 1943, after which these computations were discontinued.

PART III RESUME OF HISTORY OF INSTRUCTIONS FOR PREPARATION OF MAXIMUM MONTHLY PRECIPITATION FOR 5 MINUTES, ETC.

Beginning in 1897 and continuing through 1902 maximum monthly precipitation amounts were computed for 5, 10 and 30 minutes.

From 1903 thru 1939 amounts were computed for 5, 10, 15, 30 minutes, and 1 and 2 hours.

In 1940 and 1941 the 20-minute amount was substituted for the 15.

From 1942 through 1948 both 15 and 20-minute amounts were obtained.

Computation of monthly maximum precipitation for these periods was made optional with the Official in Charge at each station at the end of 1948 and was resumed with 1951 data. Durations for which data are obtained are at present 5, 10, 15, 30 minutes, and 1, 2, and 3 hours.

Amounts were compiled for all months, including those in which no precipitation fell (amounts then were entered as 0 or --).

PART IIIa CHRONOLOGICAL SUMMARY OF HISTORY OF INSTRUCTIONS FOR PREPARATION OF MAXIMUM MONTHLY PRECIPITATION FOR 5 MINUTES, ETC.

YEAR

1897 Maximum monthly precipitation amounts were computed for 5, 10, and 30 minutes.

1903 Maximum monthly precipitation amounts were computed for 5, 10, 15, 30, minutes, and 1 and 2 hours.

1940 The 15-minute interval was dropped and the 20 minute interval added.

1942 The 15-minute interval was resumed.

1948 Computation was made optional with Official in Charge of each station.

1951 Computations were required. Durations for which data are required are 5, 10, 15, 30, minutes, and 1, 2, and 3 hours.

PART IIIb HISTORY OF INSTRUCTIONS FOR PREPARATION OF MAXIMUM MONTHLY PRECIPITATION FOR 5 MINUTES ETC.

The first instructions (par. y of the 1897 Instructions for preparing Meteorological Forms) stated that stations having a recording rain gage will enter under "Remarks" (on the summary page of Form 1001) the maximum fall in 5 and 10 minutes and one-half hour for the month, together with the date of occurrence.

Beginning with 1903 (par. y of the 1903 Instructions for Preparing Meteorological Forms) space was provided for the entry of maximum amounts for 5, 10, 15, 30, minutes and 1 and 2 hours, and the instructions were modified accordingly.

The instructions remained unchanged through 1939. They were carried as paragraph 96 (y) in 1904; 122 (w) in 1911; 121 (w) in 1920 and 118 (w) in 1938).

In 1940 and 1941 the 20-minute amount was substituted for the 15-minute amount. Beginning in 1942 both 15 and 20 minute amounts were computed. This continued through 1948 with amounts compiled for 5, 10, 20, 30 minutes, and 1 and 2 hours.

Computation of maximum amounts was again required with 1951 data according to Circular Letter No. 6-52, with amounts compiled for 5, 10, 15, and 30 minutes, and 1, 2, and 3 hours. This continues to the present time.

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